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U. S. DEPARTMENT OF AGRICULTURE,
WEATHER BUREAU.
CHARLES F. MARVIN, Chief.

INSTRUCTIONS FOR THE
INSTALLATION AND MAINTENANCE OF
MARVIN WATER-STAGE REGISTERS
WITH SPECIFICATIONS.

CIRCULAR J, INSTRUMENT DIVISION.

BY

ROY N. COVERT,
Meteorologist.



WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1921.



PIPING FOR FLOAT AND COUNTERWEIGHT ATTACHED TO PIER OF SUSPENSION BRIDGE. CINCINNATI, OHIO. PLATFORM AT TOP OF PIPE HAS APPROACH THROUGH FLOOR OF BRIDGE.

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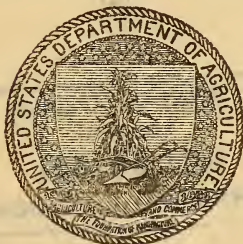
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INTRODUCTION.

The work of the Weather Bureau as regards the observation of river stages has been steadily increasing, keeping pace with the growth of industry, agriculture, and commerce. In addition to the large number of river gages which require direct reading, a considerable number of the Weather Bureau stations along the important rivers are equipped with recording or indicating registers. Besides the advantage of maintaining a continuous record of the river stages for stream-flow and flood-forecasting studies, these instruments are of particular value at the larger stations, since the height of the water can be furnished at a moment's notice in answer to inquiries, often urgent, received by telephone or otherwise.

Up to the present time the installation of these gages has been handled almost entirely by correspondence; hence the need of a publication which embodies the experience of the bureau, furnishes information not readily available heretofore, and therefore renders the installation of recording gages more simple.

INSTRUCTIONS FOR THE INSTALLATION AND MAINTENANCE OF MARVIN WATER-STAGE REGISTERS, WITH SPECIFICATIONS.

I. GENERAL DESCRIPTION.

1. *Types of registers.*—There are two principal types of registers in use in the Weather Bureau, namely, the Marvin and the Friez. The Marvin gage is employed much more generally than the others and the following information deals with that gage. However, the installation of float and counterweight pipes would be practically the same for any of the registers used. Information regarding registers other than the Marvin will be furnished on request.

2. *Arrangement of parts.*—The Marvin register is composed of two principal parts: One, the float mechanism or transmitter, located at the river; the other, the indicator, or occasionally a recorder, installed in the distant office and connected electrically with the transmitter. Stages of the river are read from the indicator to feet and tenths of a foot. Besides the instruments proper the register requires for its operation a float pipe that is essentially a still well, to which the river water has access at the bottom through lateral inlet pipes. A copper float rests on the surface of the water in the pipe, the float being suspended by a perforated bronze tape passing over a sprocket wheel in the transmitter. The weight of the float and tape is counterbalanced by a weight free to move in a smaller pipe parallel to the float pipe; all as shown in the illustrations. Vertical motion of the water in the pipe is thus communicated to the transmitter, which in turn completes the electrical circuit to the indicator for each rise or fall of a tenth of a foot.

3. The Friez gage differs from the Marvin in being non-electrical with the recorder placed directly over the float pipe.

II. FLOAT PIPE.

4. *Location.*—The float pipe may be attached to the outside of a bridge pier, as illustrated in the frontispiece, or better still installed within the pier while the bridge is in course of construction, as shown in figure 1.

5. The pipe should be located where oscillations of the water in the float pipe due to wave action or excessive current are least. It is stated by the official in charge at St. Louis that to go too far toward

the center of the stream results in placing the gage where oscillations are very likely because of whirls in the swifter current, while an installation too near shore results in excessive oscillations due to wave action. Each installation should therefore be made so as to minimize these effects.

III. INSTALLATION OF FLOAT PIPE WITHIN PIER.

6. *A typical installation* of a float pipe within a bridge pier is illustrated in figure 1. The vertical portion, A, is 8-inch standard wrought-iron pipe with flanged and bolted couplings. An 8-inch T, B, is placed at its lower end to which the horizontal 8-inch pipes, C and D, are attached. These latter make up the inlet for the water and are placed so as to make an angle of 60° with the direction of the stream flow. The inlet pipe should if practicable be located a little below the lowest water stage experienced. In order that waves in the river may not cause fluctuations in the height of the water in the float pipe, nozzles E and F are screwed to the ends of the inlet pipe and the wave action is thereby damped. The openings in the nozzles shown are three-fourths of an inch in diameter, but should be more if the river deposits silt rapidly.

7. *Upper ends of float and counterweight pipes.*—The float pipe extends to a height of about 30 inches above the top of the pier. This upper end is not threaded, but made smooth and level, and surmounted by the top flange, G, which is attached to the pipe by means of three set screws. The base plate, H, is screwed to the top flange, and constitutes the support for the transmitting mechanism. The $1\frac{1}{4}$ -inch counterweight pipe is shown at I. To complete the installation of a register, the transmitter and indicator are connected electrically to each other and to a battery, as further described below.

IV. FLOAT PIPE ATTACHED TO OUTSIDE OF PIER.

8. The method whereby the float pipe may be attached to the outside of a bridge pier is illustrated in figure 2. It will be noticed that no horizontal inlet pipe is required, but that otherwise the same sized float and counterweight pipes are used, and their lengths and arrangement are similar to those shown in figure 1. The principal difficulties inherent in such an installation are found in the construction and attachment of brackets for supporting the pipe, since the brackets are of differing dimensions to conform to the shape of the pier. Also, the pipe being external to the pier, there is possibility of injury due to passing objects in the stream, and the distance of the upper end of the pipe from the top of the pier requires the construction of a platform and means of approach thereto. The illustration

FIG. 1.—Installation of float and counterweight pipe within bridge pier.

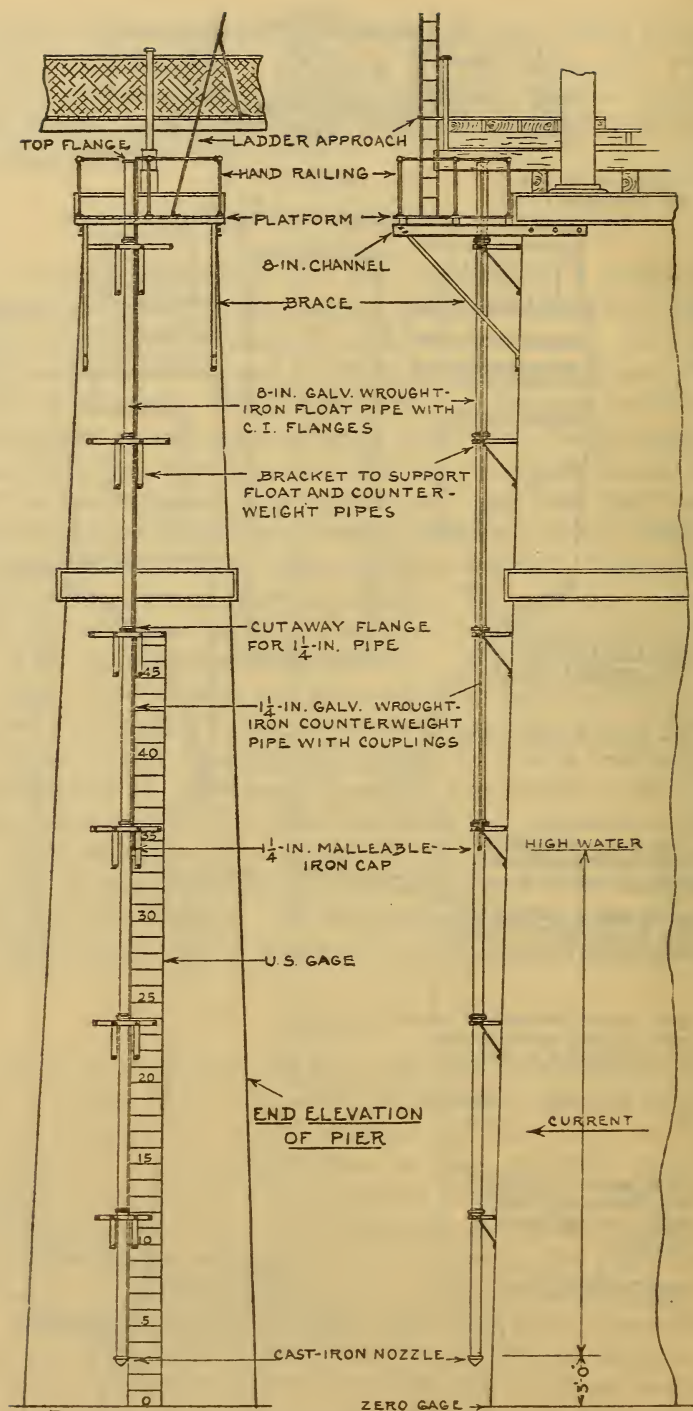


FIG. 2.—Float and counterweight pipes attached outside of bridge pier.

shown is taken from plans of an installation of a Marvin register at Charleston, W. Va., and specifications for the work at this station are given below.

Following is a detailed description of the instrumental parts of the equipment:

V. TRANSMITTER.

9. The *transmitter* consists essentially of a contact-making device which responds to changes in the level of the water in the float pipe. Referring to figure 3, A is a two-way mercury switch which selects the wires for the current flow in a three-wire circuit, while B is a second switch actuated by the governed clock mechanism, C, which serves to determine the duration of the contact and as a result the positiveness of the action of the electromagnets of the indicator. A perforated bronze tape, D, is passed over the sprocket wheel, E, and thence to the wheel F. The end of the tape below wheel F carries a counterweight, while at the other end of the tape is a 6-inch copper float which rests on the surface of the water in the float pipe. The float and counterweight are shown separately in figure 4. Changes in the height of the water cause the sprocket wheel, E, to rotate, which rotation in turn tilts the mercury switch, A, and releases the clockwork C. The electric circuit is thus closed by switch, B, for each tenth of a foot change of water level and the rising or falling magnet of the indicator energized, which produces in turn the motion of the indicator hand over the dial. (See fig. 5.) A removable iron plate, H, closes the top of the float pipe. This plate keeps much moisture from reaching the transmitter, and also prevents small articles from being dropped into the pipe.

10. *Transmitter dials, reading of.*—At G, figure 3, there is a pair of dials similar to those used in the anemometer, which, when properly set, show the exact stage of the river. These dials are read in substantially the same manner as anemometer dials as described in Circular D, Instrument Division.

11. *Exposure to weather.*—When the transmitter is exposed to the weather, it is protected by two copper covers, an inside one that covers the instrument proper and a larger outside cover hinged to the base plate and locked to the plate with a padlock. When placed in a recess in a pier, the outer copper cover is omitted.

VI. INDICATOR.

12. *Description.*—This portion of the register is illustrated in figures 5 and 6. It consists essentially of two electromagnets, one for rising and one for falling stages of the river, A and B, respectively, which produce the desired rotation of the hand over the dial through the intermediate gear wheels. The electrical connections are

made to the binding posts, C, which are also shown on figure 7, diagram of circuits. The arrow point of the face of the dial shows at any time whether the river is rising or falling. When the point is down the river is falling and vice versa.

VII. INSTALLATION OF REGISTER.

13. *Site for register.*—The first steps to be taken preliminary to installing a recorder are to secure the necessary site for the float and inlet pipes and to make certain that dependable wire service is available. Usually a bridge pier is chosen where there is a considerable depth of water present when the lowest stages of the river are reached. Another factor entering into the problem of site is the distance of the transmitter from the roadway of the bridge. These matters are handled in detail by the official in charge of the river station, under the direction of the central office, where special drawings and specifications are customarily prepared. Sometimes it is also necessary to design a suitable approach from the bridge roadway or walk to the top of the pier and the transmitter.

14. *Securing proposals for work.*—The work is usually done on contract, proposal forms being submitted to three or more bidders in the customary manner.

To illustrate what material and labor are required, the following brief specifications are submitted which apply to figure 1:

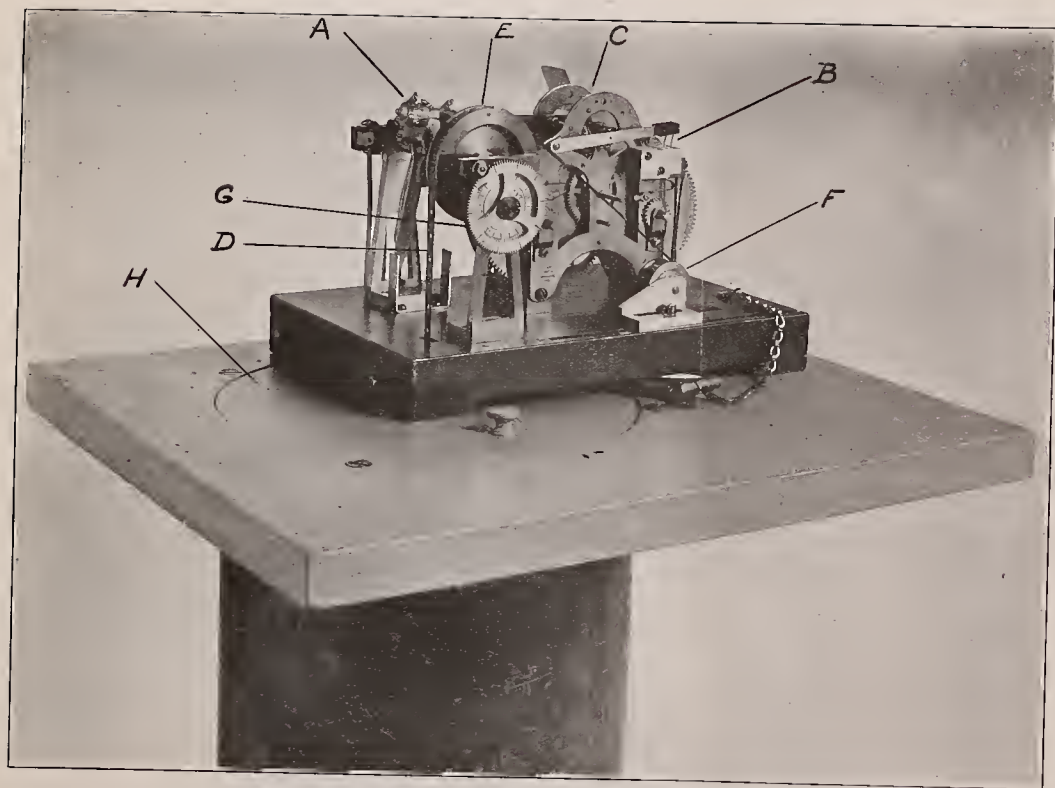
VIII. SPECIFICATIONS FOR INSTALLATION OF FLOAT AND COUNTERWEIGHT PIPES WITHIN BRIDGE PIER.

15. *Assembly of pipe.*—The float pipe shall be made up of sections of 8-inch standard weight galvanized wrought-iron pipe, with a total overall length of nearly 33 feet; the joints formed of standard cast-iron bolted flanges. The contractor should carefully verify for himself the dimensions shown on the drawing.

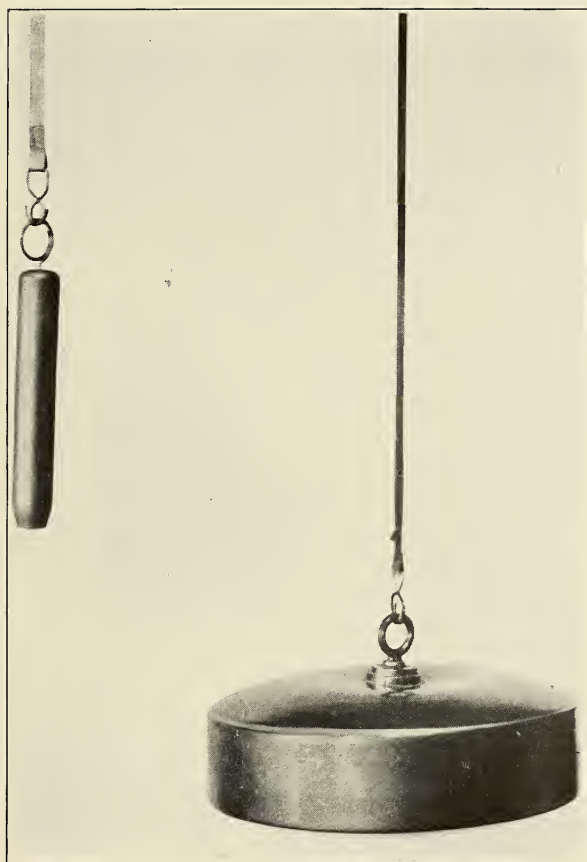
16. *Verticality.*—Attention is invited to the necessity of securing absolute verticality of the pipe in its final position. When the float pipe is in position the top end will be covered temporarily to prevent any refuse from dropping in.

17. *Nozzles.*—The ends of the inlet pipes are closed by special cast-iron nozzles screwed to the pipe, as indicated in figure 1. These castings will be furnished by the Weather Bureau, but the piping and such fittings and material as are required for the installation will be provided by the contractor. The top end of the float pipe shall be cut off square and true and not screw-threaded, the flange being attached by set screws.

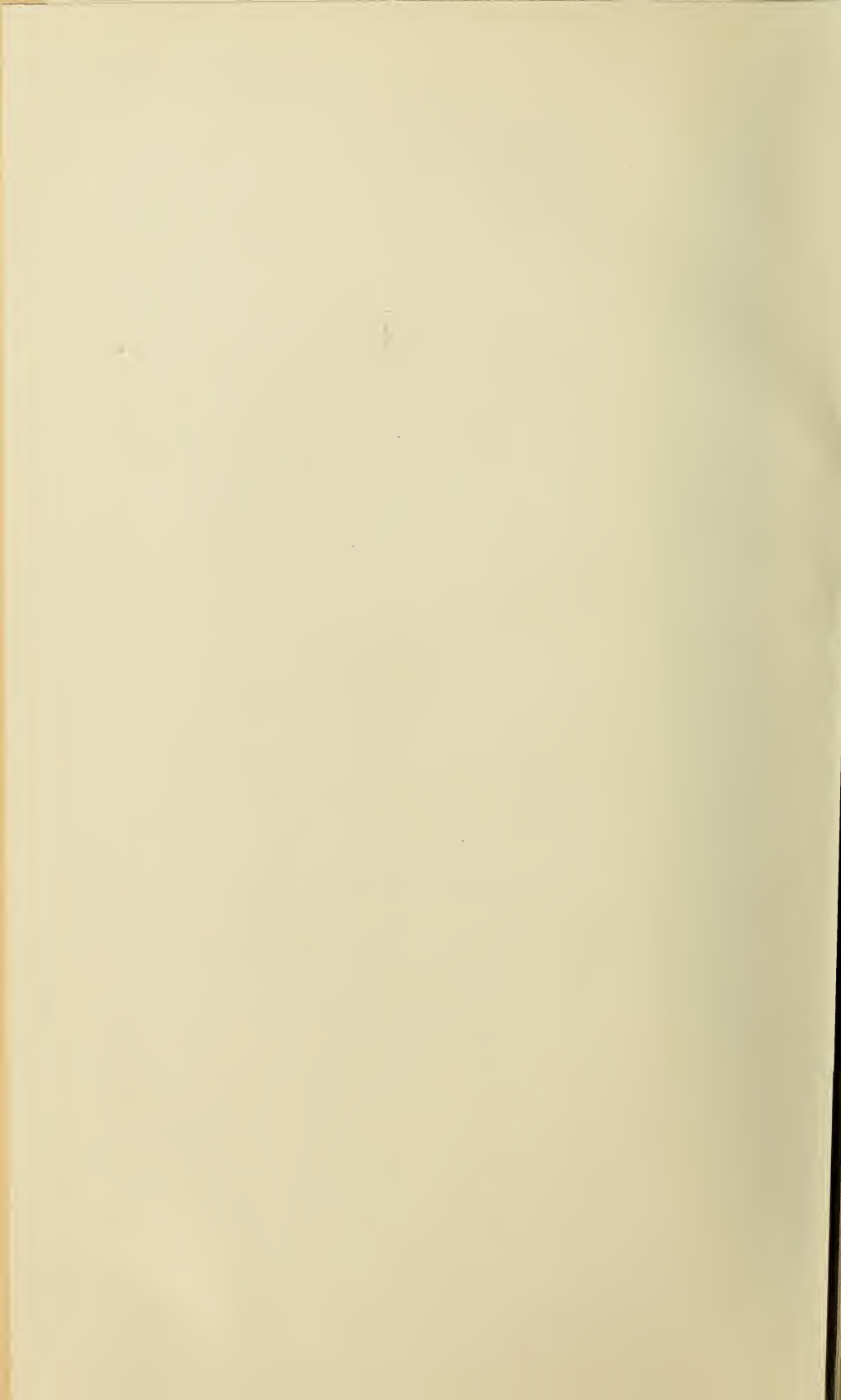
18. *The counterweight pipe* shall have an overall length of nearly 26 feet 4 inches, and be made up of sections of 1½-inch standard

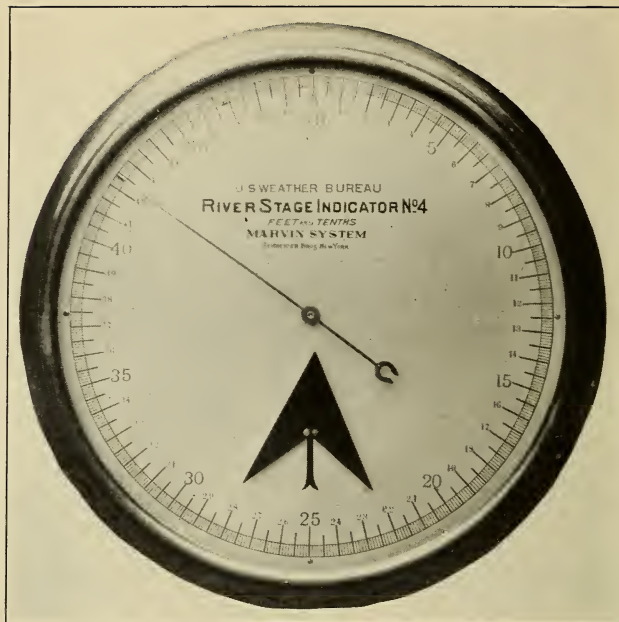


PHOTOGRAPH OF TRANSMITTER TOGETHER WITH TOP FLANGE FOR ATTACHMENT TO FLOAT PIPE.

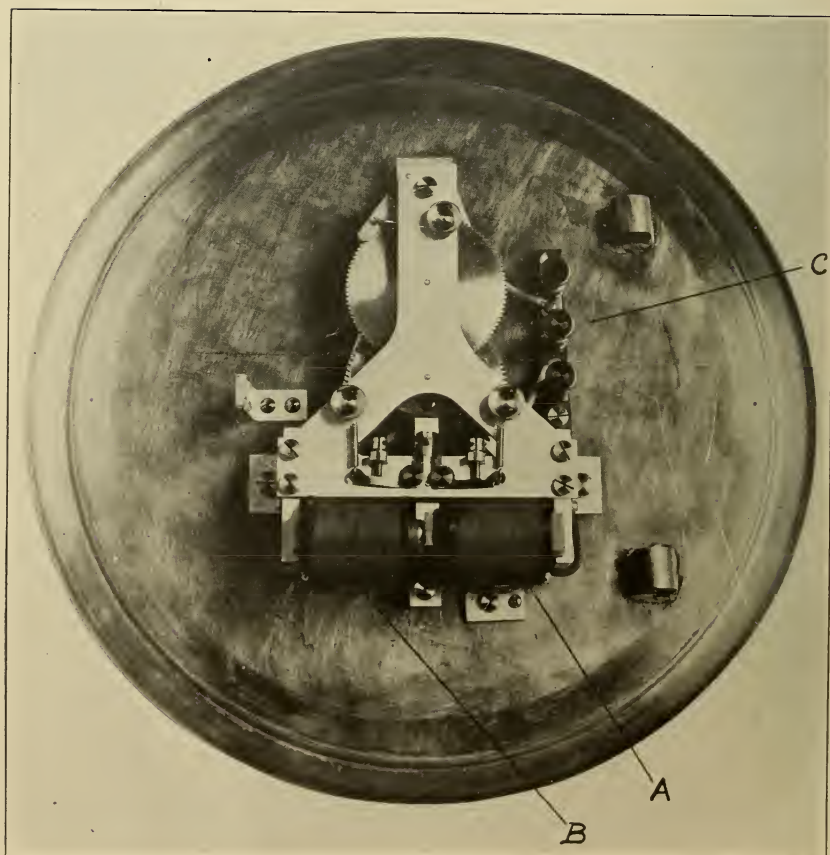


FLOAT AND COUNTERWEIGHT.





INDICATOR, EXTERIOR VIEW.



INDICATOR, INTERIOR VIEW, COVER REMOVED.

weight, galvanized wrought-iron pipe closed at the bottom with a malleable-iron cap made water tight. Screw couplings shall be used at joints, all the joints to be water tight. The center of the pipe will be accurately spaced $6\frac{1}{4}$ inches from the center of the float pipe, and it will be necessary to slightly cut away the flanges of the float pipe to permit of this spacing. The ends of the sections of this pipe shall be cut off square and true and left perfectly smooth on the inside, without any burr or other projections that would in any way interfere with the free movement up and down through the pipe of the counterweight. The top end of the counterweight pipe shall be installed so as to stand exactly $1\frac{3}{8}$ inches higher than the top of the float pipe, and be cut off true and square without a thread. The relation of float and counterweight pipes is shown in drawing.

19. *Protection from corrosion.*—All iron parts will be carefully galvanized to prevent corrosion, and where such galvanizing is removed during assembly by thread cutting, drilling, etc., these parts and such others as are scarred during assembly will be painted with red lead.

IX. LIST OF MATERIAL REQUIRED.

Two pieces 8-inch galvanized standard wrought-iron pipe each 7 feet long threaded at both ends.

One standard 8-inch cast-iron flanged T.

Two pieces 8-inch galvanized standard wrought-iron pipe each 16 feet 6 inches long threaded at both ends except one piece cut off square and true without threads.

Three standard 8-inch cast-iron flanges.

Two pieces $1\frac{1}{4}$ -inch galvanized standard wrought-iron pipe with couplings to give over-all length of 26 feet $1\frac{1}{4}$ inches, one end to be cut off square and true without threads.

One $1\frac{1}{4}$ -inch malleable-iron cap.

Five cast-iron separators for spacing float and counterweight pipes.

Two 8-inch cast-iron nozzles (furnished by Weather Bureau).

X. SPECIFICATIONS FOR THE INSTALLATION OF FLOAT AND COUNTERWEIGHT PIPES, TOGETHER WITH PLATFORM AND LADDER APPROACH; FOR USE WITH WATER-STAGE REGISTER AT CHARLESTON, W. VA.

20 (1). *General specifications.* The work will consist principally of the following parts, all labor and material with certain exceptions to be provided by the contractor:

(a) The installation of wrought-iron float and counterweight pipes on special brackets; all substantially as shown on Weather Bureau drawing No. 163 (see Figure 2), the same to be placed on

the downstream side of the pier bearing the United States gauge, on the Charleston and South Side highway bridge.

(b) The construction and installation of a platform about 8 feet square, placed near the top of the pier and provided with iron ladder to give access to the float mechanism, which will be mounted later at the top of the float pipe.

21. The work is to be done, if practicable, essentially as shown in detail on drawing No. 163, and any deviation therefrom will be made only after consultation with the engineer in charge of the work.

22. (2) The *float pipe* will be made up of sections of 8-inch standard-weight, galvanized wrought-iron pipe, with a total over-all length of nearly 74 feet, the joints formed of standard cast-iron bolted flanges. This pipe will be held in as exactly a vertical position as possible by means of several heavy wrought-iron brackets placed as shown in blue print, the flanged joints of the pipe resting on top of the outer ends of the brackets, so that no slipping of the pipe is possible. The contractor will carefully verify for himself, from measurements made on the bridge pier, the dimensions of the brackets as shown on the drawing, inasmuch as the pier is "rock face," and the projections on the face of the pier may require some modification of the dimensions given.

23. *Verticality of pipe*.—Attention is invited to the necessity of securing absolute verticality of the pipe in its final position. It is suggested that the float pipe be built up around a plumb line hung from a point at the top representing the final position of the center line of the pipe; and then make sure that the brackets, when finally fastened to the side of the pipe, hold the several sections of the pipe accurately centered. To avoid the disturbing influence of the wind, etc., a fine wire can be used for the line, and a weight, say, of 15 or 20 pounds for the plumb bob. This plummet should be lowered inside the section of pipe so as to be sheltered from wind disturbance, etc. When the float pipe is in position the top end will be covered temporarily to prevent any refuse from dropping in.

24. *Nozzle*.—The bottom end of the float pipe is closed by a special cast-iron nozzle screwed to the pipe, as indicated in the blue print. This casting is furnished by the Weather Bureau, and likewise the cast-iron top flange to which is attached the base for supporting the float or transmitter mechanism. The top end of the float pipe must be cut off square and true and not screw threaded, the flange being attached by set screws. The contractor is required to attach the flange only, the attaching of the transmitter base being left until later.

25. (3) The *counterweight pipe* has an overall length of nearly 43 feet, and is made up of sections of 1½-inch standard weight, galvanized wrought-iron pipe closed at the bottom with a malleable-

iron cap made water tight. Screw couplings will be used at the joints, all water tight. The center of the pipe will be accurately spaced $6\frac{1}{4}$ inches from the center of the float pipe, and it will be necessary to slightly cut away the flanges of the float pipe to permit of this spacing. The ends of the sections of this pipe must be cut off square and true and left perfectly smooth on the inside, without any burr or other projections that would in any way interfere with the free movement up and down through the pipe of the counterweight. The top end of the counterweight pipe must be installed so as to stand exactly $1\frac{3}{8}$ inches higher than the top of the float pipe, and be cut off true and square and without a thread. The relation of float and counterweight pipes is shown in blue print in detail of bracket, and in assembly of top flange and support for float mechanism.

26. (4) The *platform* to be provided will be carried on two 8-inch standard weight, galvanized, wrought-iron channels, securely bolted to the sides of pier immediately below the cap and suitably braced by means of steel angles, all as shown in drawing. A substantial floor of $1\frac{1}{2}$ by 6 inch cypress planks will be laid on three 4 by 4 inch cypress sleepers bolted to the channels; all thoroughly painted. The floor planks will be spaced about one-fourth inch apart.

27. A *suitable galvanized-iron hand railing* $3\frac{1}{2}$ feet high, made of $1\frac{1}{2}$ -inch standard wrought-iron pipe, will be placed around the exposed edges of the platform.

28. The *iron ladder*, shown in detail No. 10 in blue print, will be made up practically as illustrated, and one of the planks of the bridge walk will be replaced by another somewhat longer to provide suitable bracing for the ladder. If necessary it will also be attached to the railing of the bridge. Should the top of the railing and the ladder be rather difficult of access from the bridge walkway, some simple form of steps will be attached to the railing on the side to remedy the trouble.

29. (5) No cofferdam will be needed to install the pipe while the river is low.

30. (6) All iron parts will be carefully galvanized to prevent corrosion, and where such galvanizing is removed during assembly by thread cutting, drilling, etc., these parts and such others as are scarred during assembly will be painted with red lead.

31. *Material to Complete Installation.*—When the piping has been placed in position the following equipment will be needed to complete the installation:

One water-stage register, two parts:

(1) Transmitter.

(2) Indicator or recorder.

One copper float.

- One phosphor bronze tape, perforated.
- One counterweight.
- One cast-iron base plate for float pipe.
- One cast-iron top flange for float pipe.
- One small bottle of mercury for the mercury switch B of transmitter.

XI. INSTALLATION OF TRANSMITTER.

32. *Details of work.*—Referring to figure 3, the cast-iron top flange with the attached base plate is first placed over the top of the float pipe and secured with set screws. The transmitter should then be set up on blocks about 6 inches high so that easy access may be had to the float pipe and the cover to the same readily inserted. Then the float will be hooked to the perforated end of the phosphor-bronze tape and lowered to the surface of the water in the pipe. Next the other end of the tape will be threaded through the cover and the hole in the base of the instrument, and the counterweight attached and lowered into its pipe. Care should be taken not to kink the tape. The blocking may then be removed from under the transmitter and the latter attached to the base plate with the three screws at the corners. Lastly the ivory cups of switch, B, will be nearly filled with mercury, using a medicine dropper. Too much mercury should not be used nor any particles allowed to fall on the brass portions of the instrument.

XII. INSTALLATION OF INDICATOR OR RECORDER.

33. The indicator merely needs to be *securely* fastened to the wall in the office where it may be read conveniently and the electrical connections readily made thereto. In order to provide easy access to the mechanism of the indicator the cover of the instrument is hinged to the case mounted on the wall, and, should it be necessary, the whole mechanism can be entirely removed from the wall by simply withdrawing the long brass pin forming the hinge. A recorder should be placed on the instrument stand.

XIII. WIRING.

34. The *wire and battery service* is customarily secured from the local telephone company at a certain rate per annum. It is possible, however, to maintain battery in the Weather Bureau office, but the storage-battery service furnished by a telephone company is generally more satisfactory, and unless constant care of a battery can be given by the station force, rented battery service is more dependable.

35. *Type of battery.*—Occasionally dry cells are employed; Waterbury primary cells would do better, but a well cared for storage battery is preferable. Three wires, preferably not smaller than No. 18

gage, are required for a metallic circuit and a battery the voltage of which is dependent upon the length of circuit. Details relative to the electrical connections are given below.

36. *Methods of wiring.*—Figure 7 illustrates three methods of wiring, preference being given to the 3-wire metallic circuit A. The first alternative, B, is quite similar, excepting for the use of a grounded circuit from the battery to the transmitter. The second alternative, C, is least desirable and necessitates a change in the connection and insulation of the binding posts of the transmitter. It will be noticed that the line wires are attached to the two upper binding posts of the indicator, the lower instead of the middle post being grounded.

37. *Grounds.*—The middle binding post of the transmitter is attached direct to the base and will probably be well grounded through the float pipe, but if this is not sufficient a wire should be run from the post to the metal work of the bridge, a car track, or any well-grounded piping that may be reached. Grounds may be made to the indicator or battery by connection to the water piping within the building where they are located, or to specially constructed grounds outside. For the latter, a $\frac{1}{16}$ -inch copper plate of about 10 square feet may be used, buried in permanently moist earth, with a good-sized copper wire or a cable reaching to the surface and thence to the instrument. A piece of 1-inch galvanized-iron pipe driven into the earth also makes a good ground. However, water-pipe grounds will usually be available and the ground wire may be readily attached by wrapping it about the pipe and soldering when the pipe has been drained, or preferably a suitable clamp for the pipe may be provided to which the ground wire would be soldered or screw-connected.

38. *Permanency of wiring.*—The wiring at the bridge and in the office should be carefully done and protected from injury by being placed in conduit or other ducts. Necessary outside wiring at the bridge must be weatherproof. No. 16 rubber-covered wire in sherardized conduit would be most suitable for the connection from the transmitter to the telephone company's lines, which are usually run underground.

39. *Adjustment and operation of register.*—The register will operate with a battery current of from 0.2 to 0.3 of an ampere, and the circuit is closed only at relatively infrequent intervals. The proper battery voltage required to give positive action should be ascertained by trial. One way is to disconnect the three wires at the transmitter end of the circuit and join them together by means of a double connector or otherwise. Then energize each indicator magnet in turn by touching the proper line wire to its respective binding post. There should be a perfectly definite action of the mechanism both as regards

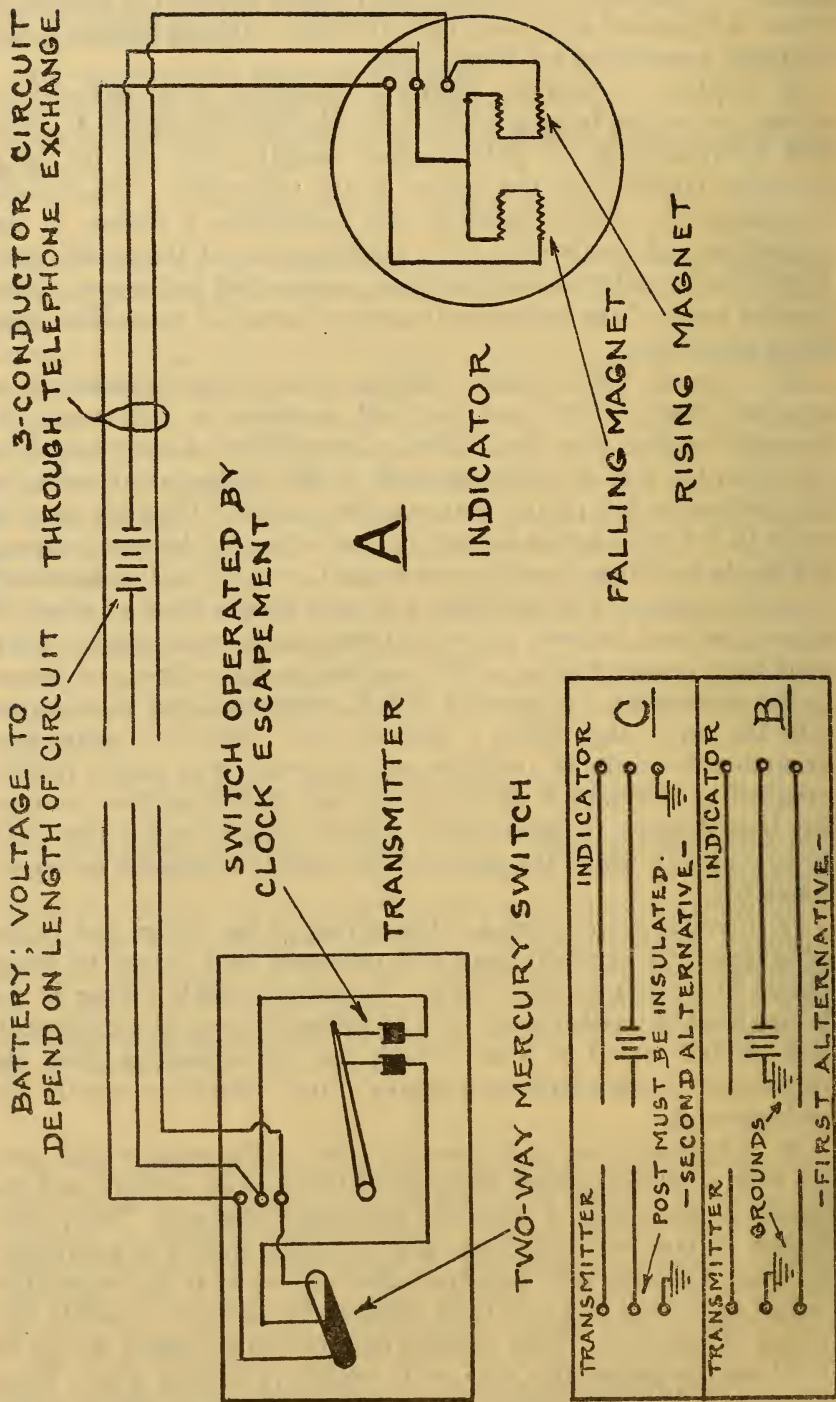


FIG. 7.—Wiring diagram for direct connection.

the motion of the index hand and the throw of the arrow from rising to falling or vice versa. The battery voltage beginning at some relatively low value should be gradually increased while the test is in progress until its proper magnitude is determined.

40. *Strength of current.*—Excessive current strength should be avoided, as it causes undesirable sparking at the mercury contacts. If the current is too small, the mechanism may fail to shift the indicator arrow, but might possibly move the hand after the arrow has been shifted.

41. The successful action of the register depends fundamentally upon an adequate and steady strength of current. The battery service must not be subject to interruption nor the voltage allowed to fluctuate greatly. However, the storage-battery service customarily furnished by a telephone company will usually be thoroughly dependable.

42. *Use of relays.*—Occasionally a long circuit of wires as small as 21 gauge becomes necessary, in which case relays have been successfully applied as indicated in figure 8. Both batteries should be adjusted to give positive action of the electromagnets, using neither too much nor too little current.

43. *Two other adjustments* are necessary before the register is ready for operation: First, the dial wheels of the transmitter should be set to read correct stages. This may be easily done by lifting the tape free of the sprocket wheel and revolving the latter until the dial reading corresponds to the true stage of the river according to the standard city gauge, when the tape is in position and the float and counterweight in equilibrium. The dials read to feet and hundredths, but it is only necessary to set them to read to the nearest tenth of a foot, since only changes of a tenth of a foot are transmitted and indicated.

44. When the dials are revolved to produce any desired reading, the precaution should be taken to lift the rocking lever from contact, so that the rapid oscillations of this lever while the clock is in motion shall not cause possible injury to some of the clock mechanism. The final setting of the dials to the actual reading may also be accomplished by loosening the set screw holding the sprocket wheel to its shaft, and then adjusting the dials to the desired value. As will be noticed, the position of the guide roller can be adjusted so that the counterweight tape centers accurately in its pipe.

45. *Setting Indicator.*—Having ascertained the stage of the water at the river and made a final setting of the float and sprocket wheel so that the dial reading corresponds with that of the existing stage of the river, it will then be necessary to set the indicator hand so that its reading also indicates the true stage. This can be done by

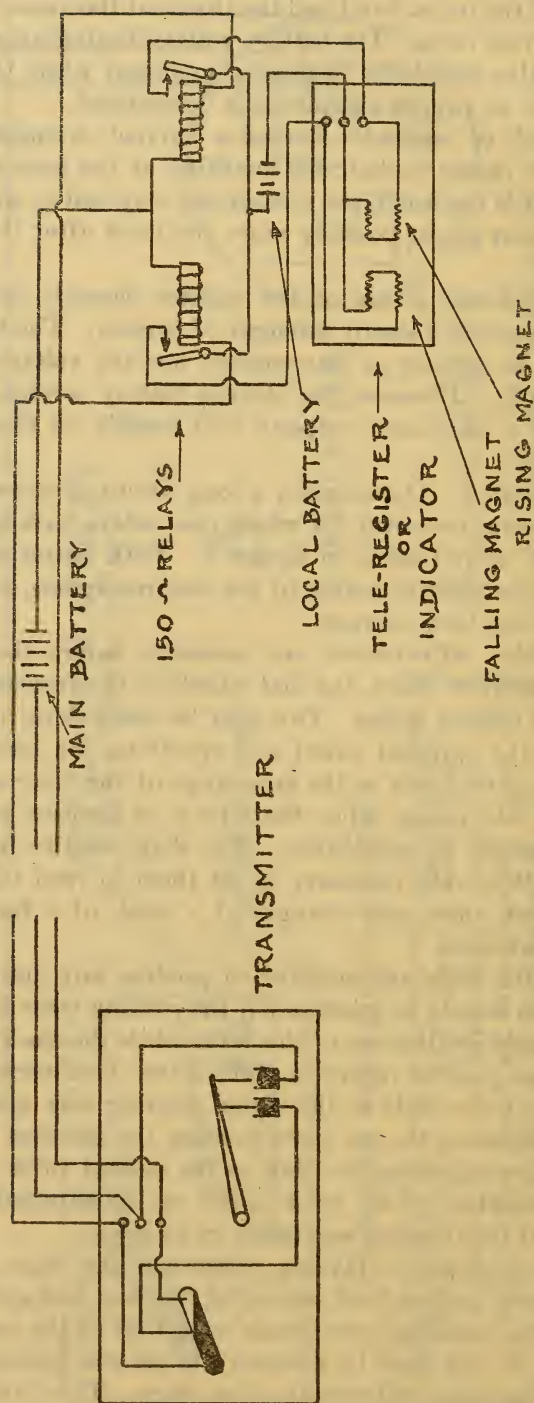


FIG. 8.—Wiring diagram using relays for local circuit.

opening the indicator and simply revolving the large, main-notched wheel at the center of the back of the dial until the desired indication of the index hand is produced. The arrow-head may also be set to indicate whether the river is rising or falling if this is known at the time, but it does not matter greatly whether the arrow is set or not as it will assume the right position when the first change of one-tenth of a foot in the stage of the river occurs. After this time the indicator readings and the stage of the river should correspond with each other at all times, unless there is some failure due to lack of battery of other faults in the system.

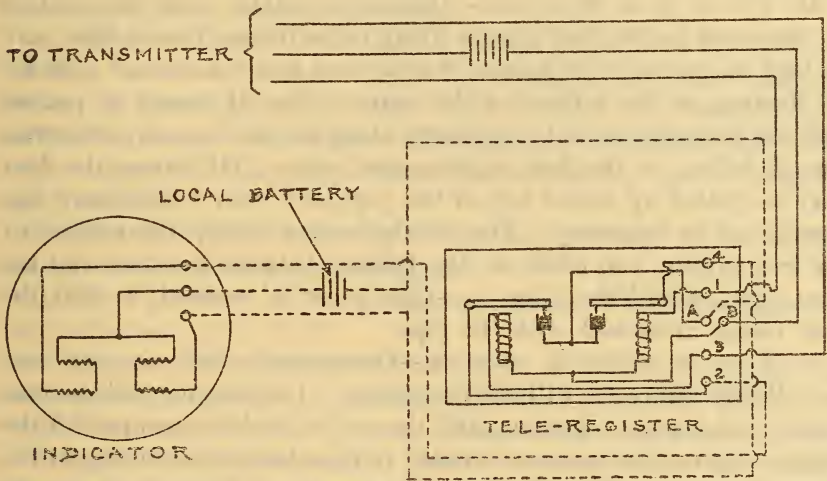


FIG. 9.—Wiring diagram using lightning arresters.

XIV. PROTECTION AGAINST LIGHTNING.

46. *Use of lightning arresters.*—The wiring for water-stage registers is usually underground, but occasionally a pole line becomes necessary. It is a good rule followed by some telephone companies to use arresters, when the pole line exceeds four spans, and the same rule should be applicable to pole lines in connection with water-stage registers to protect the delicate and expensive mechanism against lightning.

47. *Wiring for arresters* is shown in figure 9. The arrester required is the metal block, open-space cut-out used by most telephone companies. Two pairs of blocks are employed, one pair for each side of the line. One block of each pair is connected to ground, and the other to the line. The blocks are separated by a thin sheet of mica 0.01 of an inch thick. This mica has an opening in the center to allow the lightning discharge to pass from one block to the other and

thence to ground. The blocks are held in place by a simple spring assembly. An air gap of 0.01 of an inch will break down at about 350 volts pressure.

XV. CARE OF REGISTER.

48. *Oiling, care of clock.*—The bearings of the sprocket-wheel axis and the small guide roller for the chain should be oiled occasionally with clock oil. The clock movement of the transmitter being once wound up requires rewinding only at long intervals, for the clock movement is capable of making many electrical contacts without rewinding.

49. *Use of oil in float pipe.*—During the winter when the surface of the water in the float pipe is likely to be frozen, the register may be kept in operation by means of a layer of 5 or 6 inches of cylinder oil floating on the surface of the water. The oil should be poured into the float pipe so as to run down along the inside wall; otherwise the oil falling on the float might cause injury. Of course, the float may be pulled up to the top of the pipe, but with a little care this should not be necessary. The oil also serves to stop the rusting of the iron piping, and tends to stop friction between the float and the float pipe, should the latter be slightly out of vertical, so that the float comes in contact with the pipe.

50. *Care of electrical contacts.*—Occasionally the mercury contact, B (see figure 2), will need attention. The mercury will become fouled and require replacing, and the oxide should be scraped off the platinum pins that become corroded in time because of arcing of the electric current as the pins leave the mercury. Excessive arcing is an indication of too much battery voltage.

51. *Method employed in caring for register.*—The care of the register should not involve any more trouble than that usually experienced with the other Weather Bureau instrumental equipment, and failures, if not obvious, may be corrected somewhat as follows:

52. Suppose the indicator fails to keep step with the transmitter and the dials of the latter agree with an eye reading of the standard gauge. There are several possible sources of failure as follows, tests for which may be applied one after the other until the cause of the failure is located.

53. (1) *Strength of current.*—The strength of the electric current may be too low, so that either the rising or the falling magnets of the indicator fails to operate at times, and one may fail oftener than the other.

54. *Remedy.*—See that the voltage of the battery is brought up to the value determined as correct when the register was first put in

operation (see paragraph 39) so that the action of the magnet is positive.

55. (2) *The mercury switch*, B, may occasionally fail to operate.

56. *Remedy*.—Clean the platinum wires and renew the mercury.

57. (3) *Loose or corroded wires*.—The connections of the wires to binding posts at either transmitter or indicator may be loose or partly corroded.

58. *Remedy*.—Clean wires and fasten in binding posts carefully and tightly. If corrosion is occurring at the transmitter, a little vaseline rubbed on the posts and wire will help clean the holes in the binding posts. The rest of the brass parts of the instrument may be protected from corrosion likewise.

59. (4) *Wave action* in the float pipe may cause rises and falls of the float that are not followed rapidly enough by the contact-making devices, so that more contacts may occur during a rise than during a fall or vice versa. This defect is fundamental and should not ordinarily occur if the float pipe and nozzles have been properly designed and installed.

60. *Remedy*.—Reduce the size of the opening in the nozzle so that the wave action is effectively damped.

61. (5) *Failure of the indicating mechanism*.—This should occur very infrequently, if at all.

62. *Remedy*.—Operate the indicator with the transmitter detached and properly adjust the mechanism until there is positive action.

63. *Reporting trouble to central office*.—If the above tests do not remedy the trouble, the matter should be reported to the central office and the defective apparatus replaced or such other action taken as is necessary.

64. *Use of telephone*.—In making tests that require communications between a man stationed at the transmitter and another at the office, a telephone should be used, if possible. If two local battery telephone sets are available the register wires themselves may be employed for line wires. Otherwise the two persons making the tests must resort to some prearranged plan that is necessarily difficult to follow.

65. *Cleaning float pipe*.—It will probably be necessary to clean the sediment out of the inlet pipes every few years or oftener, because the lower end of the float pipe with which no inlet pipes are used may become obstructed. This cleaning can be effectually done only when there is low water, and the removal of the nozzles is necessary if mechanical cleaning is resorted to. It should be possible, however, to avoid the removal of the nozzles and accomplish the cleaning by running water into the upper end of the float pipe for a considerable length of time, using enough of it to maintain a high head of water

in the float pipe. A strong flow of water would then take place from the float and the inlet pipes to the river and a large part of the sediment should go along with the water. Of course the float would have to be removed. The water from a 1½-inch hose connected to the city supply should usually be sufficient, but in case the city supply is not available a portable pump could be used and the water taken from the river. Some officials have had a locomotive tender placed at their direction for this purpose.

66. *Frequent attention required.*—In general, it can be said that an automatic gage of this character can not be expected to give reliable readings unless it is given frequent attention. "The idea that an automatic gage lessens the work of river observations is erroneous; the work is very much increased, but the results obtained more than

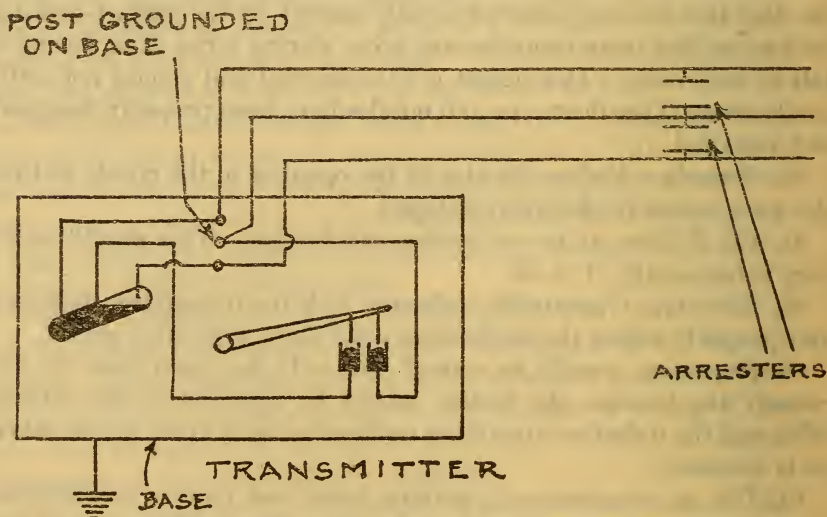
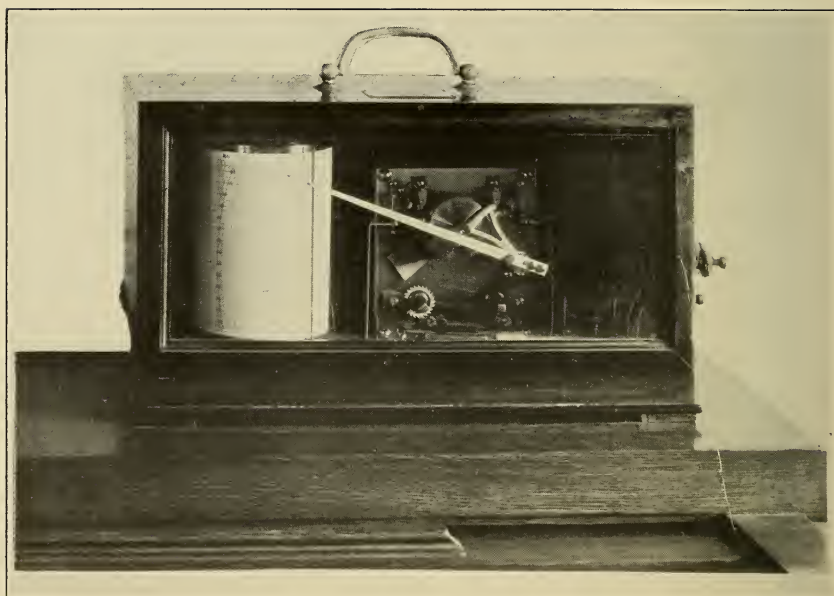


FIG. 10.—Wiring diagram for recorder or teleregister.

compensate the office for the increase in work." (Montrose W. Hayes, official in charge, St. Louis, Mo.)

XVI. WATER-STAGE RECORDER.

67. At a few river stations the indicator has been replaced by a recorder. Telethermograph recorders of the kind shown in figure 11 are used for this purpose, suitable record sheets being provided to correspond to the range of river stages at the station. The diagram of circuits for this recorder and its connected transmitter is shown in figure 10. It is possible to operate the indicator along with the recorder at the same time, but such an arrangement may usually be dispensed with. This is accomplished by the wiring indicated by dotted lines in the figure, a local battery being used between the recorder and indicator.



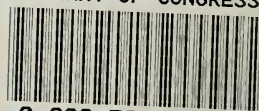
TELEREREGISTER FOR USE IN PLACE OF INDICATOR.

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